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Les articles en anglais ou en français doivent être adressés au secrétaire du Comité de rédaction, Services de l'information, Agriculture Canada, Ottawa K1A 0C7.

COVER
Saskatchewan grain elevators symbolic of Canadian quality wheat.

COUVERTURE
Silos-élévateurs de la Saskatchewan, symbole de qualité du blé canadien.

TWELVE YEARS OF AN INTERNATIONAL APPROACH TO THE EUROPEAN CORN BORER

M. HUDON

Members of the IWGO visiting the St. Jean Research Station in October 1974.

Since 1969, Canada has been a participating partner in a comprehensive international research program on the European corn borer *Ostrinia nubilalis* (Hübner). Maize is the world's third most important crop after wheat and rice. Since the European corn borer is a threat to maize crops in many countries in the world, a global approach to the problem was necessary. The Canadian arm of the research arrangement is centered at Agriculture Canada's Research Station, St. Jean, Quebec.

The International Working Group on *Ostrinia* (IWGO) was created by D. Hadžistević of Yugoslavia and a group of entomologists from Hungary, Poland, Roumania, the United States, and the U.S.S.R. who were attending the 1968 International Congress of Entomology in Moscow. In 1969, entomologists from Austria, Canada, France and a maize breeder from Spain joined the group. This informal group committed itself to an international cooperation and research on this worldwide menace to maize crops.

To facilitate analyses and interpret results, the 10 participating countries agreed to follow standardized experiments, materials, methods, and sampling procedures.

The aim of the working group was to develop a better knowledge of the corn borer and of its relationships with its main host-plant *Zea mays* L. in different environmental conditions. The project's first objectives were then primarily to study the survival of the corn borer population on several inbred lines at research stations in the cooperating countries, to determine the type and extent of damage inflicted on host plants and to obtain more knowledge of the insect and its adaptation to maize plants under different environmental conditions.

During the past 12 years, a new objective for IWGO has evolved to select early resistant maize and to breed from it promising germplasm incorporated into inbred lines available to all world maize breeders.

During that time, entomologists and maize breeders from six other countries, including Bulgaria, Czechoslovakia, India, Italy, the Philippines and Portugal have joined the IWGO.

During the past 12 years, IWGO has developed five 2-year projects, discussed during ten annual symposia held in nine countries: Austria (1969), Yugoslavia (1970), France (1971), Hungary (1972), Yugoslavia (1973) in connection with the EUCARPIA meeting, the United States and Canada (1974), the U.S.S.R. (1975) in connection with the 8th International Congress of Plant Protection, Spain (1976), Poland (1977) and Italy (1978). A coordinator was elected for each symposium who organized the research program for the coming year, collected the data, and arranged for his country to host the next symposium.

Professor H.C. Chiang from the University of Minnesota was the first coordinator and has become the president of IWGO. Each year, this unique worldwide research program is conducted by each participant with the existing equipment and financial resources of his own research station without international sponsorship. Results of activities of the IWGO have been published in three reports: Phase I (1973), Phase II (1975) and Phase III (1976) by the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Publications by members in their respective countries keep research information about the project available.

Since 1969, IWGO members have annually exchanged two late and two early types of maize inbreds per country. The standardized procedures developed during the early years have made it possible to compare and integrate the results obtained. The experimental design followed in all countries to compare data on plant injuries

after heavy artificial corn borer infestation was first developed in the early 1960's by a team of researchers at Ankeny, Iowa, and now used worldwide. Data are now being sought on the following: plant growth, plant injury (leaf feeding when plant is at the whorl stage and total plant damage determined at harvest time) from visual ratings within the field; borer survival and length of tunneling within the stalk. Since 1969, more than 500 inbreds have been evaluated for borer resistance in 16 different ecological conditions with different borer races. All data are collected annually and freely exchanged among participating members. To fulfill an international agreement, IWGO has created with the cooperation of France and Spain, synthetic varieties developed from the best resistant inbreds. According to the representative of France, the synthetics were created from material obtained from Bulgaria (BGPP276), Canada (CO239), France (F505 and F257), Hungary (MRI2), Italy (LO20, LO516 and IB041), Spain (EAI349 and EA2586), the United States (A613 and A665) and Yugoslavia (ZPL52 and ZPSC67B). Important practical results are expected from such promising germplasm, and the exchange and testing of new inbreds will be maintained for the coming year along with work on improved standard lines.

In addition to the host-plant resistance project, studies on biological control of the corn borer were developed. The Hungarian representative drew attention to the need for a new critical survey on the worldwide status of corn borer host plants. Recently a team of Iowa researchers investigated the intraspecific pheromonal variability of the corn borer in North America and Europe. Several blends of isomers used in sex traps confirmed that male corn borers exhibited intraspecific variability in their sex-pheromone response in some countries.

Numerous findings by IWGO have been published. For example, lines that were considered resistant in their country of origin were observed to be susceptible under different ecological conditions or with different borer populations, or both. Such information was extremely important for worldwide corn borer resistance maize breeding programs. In comparing Canadian data with pooled 10-country means, it was found that in some countries, in a given year of observation, variations for resistance in some inbreds disappeared in the 10-country average, indicating that local environmental conditions, the genetic make-up of the corn borer or both may alter the response of the inbred. The average response of some inbred lines from different geographic areas was more representative for their genetic characteristics. These results substantiated the IWGO researchers' initial expectations that testing host plants in wider areas would provide more opportunity to identify promising material. Corn borer resistance genes in maize are widely scattered geographically and it is possible to cumulate them by adequate breeding programs using artificial infestation

Postage stamps from around the world symbolize the exchange of research information initiated and maintained by the IWGO group

Ces timbres-poste d'un peu partout à travers le monde symbolisent l'échange de renseignements scientifiques qui s'échangent les membres de l'IWGO

methods. The detrimental or resistant factor in the behavior of different lines was found to be genetic or ecological and not purely of a biochemical origin.

The French representative suggested that when selecting corn borer resistant lines, both leaf feeding and total plant damage at harvest had to be considered. However, the *maturity* of the inbreds had great influence on the results of leaf feeding, plant damage, and borer survival. Earliness was positively correlated with leaf feeding but was negatively correlated with plant damage at harvest and with borer survival. It was then proposed that for evaluating resistance, that maize inbreds of similar maturity should be used. However, for late maize (leaf feeding, borer survival and total plant damage ratings being positively correlated), ratings on leaf feeding one month after artificial plant infestation would be sufficient and save time at the fall dissection. Because of greater strength, late inbreds are generally more resistant and have less stalk breakage. Screening maize inbreds for corn borer resistance remains delicate: in years of low rate of larval establishment and survival, inbreds may appear resistant while in other years, plant infestation may be heavier because of favorable climatic conditions for borer survival, as well as less insect predation and parasitism.

From a unique experiment in the history of entomology in the U.S.S.R. and Canada, Soviet colleagues reported heavier fecundity of corn borer moths reared on susceptible lines.

Completely reversed results of the same experiment were obtained in Quebec with the same maize lines. The Soviet scientists concluded that the lesser moth fecundity from susceptible maize in Quebec was due to the presence of a single generation (univoltine) borer in that Province. Maize plants had been artificially infested at a later stage of physiological growth than in the U.S.S.R. where two generations of the insect (bivoltine) prevail. Finally, plants in Quebec have less of the resistance biochemical factor called DIMBOA at infestation time (pollination); this normally reflects *antibiosis* of the plants to newly hatched borers. It proved that voltinism of the borer and physiological maize development were important and, different in the two countries. In Quebec, with larvae boring into plants during the entire growing season, total plant damage at harvest time was as important as leaf feeding for maize resistance evaluation.

After 12 years of cooperation among IWGO researchers, the valuable exchange of information, material, and results from this international project; the permanent contacts established among worldwide recognized authorities on maize insects and host plant resistance; and the increased ties among North America, Europe, and other parts of the world remain the most important results of this unique scientific alignment. Such international cooperation should be more recognized and encouraged throughout the scientific world.

*and the IWGO co-operators.

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DOUZE ANNÉES CONSACRÉES À UNE ÉTUDE INTERNATIONALE SUR LA PYRALE DU MAÏS

M. HUDON

Le Canada participe depuis 1969 à un projet coopératif international sur la Pyrale du maïs, *Ostrinia nubilalis* (Hübner). Parmi les cultures les plus importantes dans le monde, le maïs occupe le troisième rang après le blé et le riz. La Pyrale du maïs demeure un ennemi redoutable dans un grand nombre de pays où l'on cultive cette céréale et un effort collectif pour combattre cet insecte s'est avéré nécessaire de la part des chercheurs de ces pays. La contribution canadienne est réalisée à la Station de Recherches d'Agriculture Canada à Saint-Jean (Québec).

Le Groupe international de tra-

vail sur *Ostrinia* (International Working Group on *Ostrinia*, IWGO) a été créé par le Dr Hadžistević de Yougoslavie et un groupe d'entomologistes de la Hongrie, de la Pologne, de la Roumanie, des USA et de l'URSS qui participaient au congrès international d'Entomologie tenu à Moscou en 1968. Dès 1969, des entomologistes de l'Autriche, du Canada, de la France et un sélectionneur de maïs de l'Espagne sont venus se joindre à l'équipe. Maintenant, le groupe s'est entendu pour coopérer sur une base internationale de recherche sur cet insecte d'importance économique mondiale.

Afin de faciliter l'interprétation des résultats obtenus, les représentants des dix pays coopérants à ce projet ont accepté de standardiser le protocole expérimental ainsi que l'équipement et les méthodes d'échantillonnage.

Le but du Groupe de Travail était d'acquérir une meilleure connaissance de la Pyrale et de son comportement sur sa principale plante-hôte, le maïs *Zea mays* L. dans des conditions écologiques différentes. Les premières études ont donc porté sur la survie larvaire de la Pyrale amenée à se développer sur de nombreuses lignées de maïs grain évaluées dans des stations de recherches des dix pays coopérants, sur l'évaluation des différents types de dégâts larvaires causés à ces lignées et sur la capacité d'adaptation de cet insecte à diverses conditions d'environnement.

Pendant les 12 années d'existence de ce projet international, un nouvel objectif est venu s'ajouter en ce qui concerne la sélection de maïs précoces et résistants à la Pyrale en vue de créer du matériel génétique disponible pour tous les sélectionneurs du monde entier. Pendant ce temps, des entomologistes et sélectionneurs de maïs de six autres pays, notamment de la Bulgarie, de l'Inde, de l'Italie, des Philippines, du Portugal et de la Tchéchoslovaquie, sont venus joindre les cadres du IWGO.

Au cours de ces 12 ans, l'IWGO a développé cinq projets de 2 ans qui ont fait l'objet d'étude et de discussion lors des symposia annuels tenus en Autriche (1969), en Yougoslavie (1970), en France (1971), en Hongrie (1972), en Yougoslavie (1973), aux USA et au Canada (1974), en URSS (1975) en coopération avec le 8e congrès international de la Protection des Plantes, en Espagne (1976), en Pologne (1977) et en Italie (1978). A chaque symposium, un coordonnateur fut élu responsable de l'organisation du programme de recherche pour l'année suivante, de la banque de données recueillies et du choix du pays pour le prochain symposium.

Le professeur H.C. Chiang de l'Université du Minnesota a été le premier coordonnateur du groupe et est devenu le président du IWGO. A chaque année, ce programme de recherche, unique au monde, implique chaque représentant des pays participants avec les ressources financières et matérielles de leur Station de recherche respective, sans l'aide d'aucune organisation internationale reconnue. Toutefois, les résultats des activités du groups IWGO ont fait l'objet de trois rapports Phase I (1973), Phase II (1975) et Phase III (1976) publiés par l'Institut de recherches agricoles de l'Académie des Sciences de la Hongrie à Martonvásár. De nombreuses publications produites par les membres de ce groupe dans leur propre pays

Marcel Hudon de la Station de St-Jean (Québec) est le représentant du Canada de l'IWGO.

ont aussi permis de divulguer une bonne partie des résultats obtenus.

Depuis 1969, les membres de l'IWGO ont échangé, chaque année, deux lignées hâtives et deux lignées tardives de maïs grain provenant de leur pays respectif. Le même protocole expérimental du début est suivi dans chacun des pays coopérant à ce projet et a permis de comparer et d'intégrer pour fins d'interprétation, tous les résultats obtenus, notamment en ce qui a trait à l'évaluation des dégâts causés aux lignées sous observation, après une forte infestation artificielle de la Pyrale. Ces méthodes d'échantillonnage ont été mises au point au début des années 1960 par une équipe de chercheurs du laboratoire sur la Pyrale du maïs d'Ankeny, Iowa, et maintenant utilisées dans le monde entier. Les données obtenues font état principalement du développement des plants de maïs et des dégâts causés par la Pyrale. Ces dégâts sont évalués selon une échelle reconnue par l'équipe

internationale et portent sur la criblure du feuillage lorsque les plantes sont au stade végétatif de cornet et sur la brisure des tiges à la récolte; on tient compte aussi de la survie larvaire et de la longueur des galeries causées par les chenilles à l'intérieur de la tige principale des plantes. Depuis 1969, plus de 500 lignées de maïs grain provenant de 16 régions possédant des conditions écologiques différentes, ont été évaluées en présence de races de Pyrale différentes. Toutes les données sont recueillies annuellement et échangées librement parmi les représentants des pays participants. Après une entente internationale, l'IWGO a créé en collaboration avec la France et l'Espagne, des variétés synthétiques, provenant des meilleures lignées précoces et résistantes. Selon le représentant de la France, ces variétés synthétiques ont été créées avec des lignées provenant de la Bulgarie (BGPP276), du Canada (CO239), de la France (F505, F257), de la Hongrie (MR12), de l'Italie (LO20, LO516, IBO41), de l'Espagne (EA1349, EA2586), des USA (A613, A665) et de la Yougoslavie (ZPL52, ZPSC67B).

L'échange et l'évaluation de ces variétés synthétiques ainsi que des lignées de maïs reconnues seront maintenus pendant les prochaines années et on s'attend d'en retirer des résultats pratiques.

Outre le projet sur la résistance du maïs à la Pyrale, il y a des études sur la lutte biologique de l'insecte. Le représentant de la Hongrie a attiré l'attention sur l'importance d'un recensement mondial des plantes-hôtes de la Pyrale du maïs. Récemment, une équipe d'entomologistes de l'Iowa ont étudié la variation intraspécifique d'une phéromone de la Pyrale du maïs en Amérique du Nord et en Europe. Plusieurs mélanges d'isomères utilisés dans les pièges à captures ont confirmé que le comportement sexuel phéromonal des papillons mâles peut varier selon les pays.

Plusieurs données ont été publiées par l'IWGO. Ainsi, il est maintenant connu que des lignées de maïs considérées résistantes à la Pyrale dans leur pays d'origine sont classifiées comme sensibles dans des régions écologiques différentes ou en présence de races de Pyrale différentes ou soumises à ces deux phénomènes. Ces observations demeurent très importantes pour tous les programmes d'amélioration du maïs pour sa résistance à la Pyrale dans le monde. Si l'on compare les données obtenues au Canada avec la moyenne des résultats des dix pays à l'origine du projet, on constate que la résistance de certaines lignées observée pendant une année d'évaluation dans certains pays disparaît lorsqu'elle est confondue dans la moyenne des données des dix pays, ce qui indique que, soit les conditions écologiques locales, soit les particularités génétiques de la Pyrale ou ces deux facteurs réunis peuvent changer l'attractivité d'une lignée de maïs vis-à-vis de l'insecte. L'attractivité de lignées de maïs dans des aires géographiques différentes a été plus significative que la performance de ces lignées dans leur pays d'origine.

Ces résultats confirment l'idée émise dès le début par des chercheurs de ce groupe à savoir que les essais de maïs dans des aires géographiques différentes favorisent la sélection de matériel génétique résistant. Les gènes de résistance des maïs à la Pyrale sont géographiquement distribués et grâce à des programmes utilisant des techniques d'infestation artificielle, il devient possible aux sélectionneurs de collectionner ces gènes. La résistance des maïs vis-à-vis de cet insecte présente un aspect génétique ou écologique, et non purement biochimique.

A la suggestion du représentant de la France, les critères de sélection de maïs résistant à la Pyrale sont la criblure du feuillage à la pollinisation et les dégâts totaux à la récolte. Par ailleurs, il estime que l'on doit tenir compte de la *maturité* des maïs lorsque l'on utilise les critères mentionnés. La maturité des maïs est reliée positivement à la criblure du feuillage, mais non aux dégâts totaux à la recolte ou à la survivance larvaire. Dans des essais comparatifs de résistance à la Pyrale, il vaut mieux s'en tenir à des maïs ayant une même maturité. Cependant, chez les maïs tardifs, comme la criblure du feuillage, le nombre de chenilles et les dégâts totaux à la récolte sont intimement reliés, l'évaluation de la résistance peut se baser uniquement sur la criblure du feuillage, un mois après l'infestation artificielle de Pyrale, ce qui représente une économie considérable de temps pour les échantillonnages. Une plus grande robustesse chez les lignées tardives les rend plus résistantes à l'insecte et à la verse. L'évaluation de maïs pour leur résistance à la Pyrale demeure une opération délicate: certaines années où l'établissement des chenilles dans les plantes se fait plus difficilement, des lignées de maïs peuvent sembler résistantes; pour d'autres années, l'infestation de la Pyrale peut être plus forte à cause des facteurs climati-

ques favorables pour la survivance des chenilles aussi bien qu'une absence de prédation ou de parasitisme chez *O. nubilalis*.

Une expérience unique dans l'histoire de l'entomologie de l'URSS et du Canada a permis aux chercheurs soviétiques de rapporter une fécondité accrue chez les papillons femelles de la Pyrale qui se nourissaient sur des maïs sensibles à l'insecte. Des résultats contradictoires ont été obtenus au Québec avec les mêmes lignées de maïs. Les Soviétiques concluent qu'une fécondité réduite des femelles observée au Québec sur des maïs sensibles était due à la présence de la race univoltine de Pyrale, et au fait que les plantes de maïs étaient infestées artificiellement à un stade de développement plus avancé qu'en URSS, où la race bivoltine de Pyrale existe. Les plants de maïs au Québec contiennent moins du facteur biochimique de résistance à la Pyrale (appelé DIMBOA) au moment des infestations artificielles, ce qui reflète une action d'antibiose moins prononcée des plantes chez les jeunes chenilles. Le voltinisme chez *O. nubilalis* et les stades de développement du maïs demeurent donc importants au Québec et en URSS. Au Québec, pour évaluer la résistance des maïs en présence d'une race univoltine de Pyrale qui se nourrit sur les tiges de maïs jusqu'à la récolte, les dégâts totaux à l'automne demeurent aussi importants que la criblure du feuillage causée par les jeunes chenilles au stade préfloral.

Après douze ans de coopération, les membres de ce projet international ont eu l'occasion d'échanger beaucoup d'information entomologique, du matériel génétique et des résultats scientifiques. Les nombreux contacts de collègues du monde entier intéressés à ce projet ainsi que les nombreuses liaisons scientifiques créées parmi les chercheurs de l'Amérique du Nord, de l'Europe et d'autres parties du monde demeurent le résultat le plus important de ce projet coopératif unique. Une expérience internationale de la sorte devrait être connue davantage et encouragée parmi le monde scientifique.

*et les collaborateurs de GITO (Groupe international de travail sur Ostrinia).

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SOLAR HEATING OF GREENHOUSES

P. VAN DIE

L'augmentation du coût de l'énergie affecte l'horticulture en serre bien plus que les autres secteurs de l'agriculture. On se sert de plus en plus de l'énergie solaire mais tant que l'économie réalisée ne compensera pas assez rapidement l'investissement d'installation, la conversion au chauffage solaire sera lente. Il semble que des mesures de conservation combinées à la ré-utilisation des rebus de l'industrie obtiennent plus aisément la faveur des horticulteurs en serre. Il y a cependant beaucoup de recherche sur l'énergie solaire faite au Canada.

As energy costs continue to soar, Canada's greenhouse industry has been hit harder than possibly any other sector of the nation's agricultural business.

In 1977 — before some of the more recent major price increases for fossil fuels — greenhouse operators were paying out 29 cents for energy for every dollar of vegetable sales. These high fuel costs have made the greenhouse industry unsure of its future, and reluctant to invest in their operations unless returns are assured and have short payback periods.

Agriculture Canada engineers say that this attitude also applies to alternate heating systems, such as solar energy. Unless savings on annual energy bills will quickly pay off the capital cost of converting to solar heating, greenhouse operators are reluctant to switch. Capital intensive solar heating systems

will therefore not be readily accepted by the industry because they are not seen and evaluated in their real perspective. Instead, conservation measures and the use of waste heat from industry is probably the route that the greenhouse industry will follow in the immediate future.

Greenhouses already receive a substantial portion of their heating requirements from solar energy. Estimates vary between 22 and 32 per cent. A large amount of solar energy is not available for heating in any event; night-time requirements are about two-thirds of the 24-hour total.

As defined at the Engineering and Statistical Research Institute a solar greenhouse is one that predominantly uses solar energy for heating, with the use of additional energy from other sources during periods of extreme low temperatures or heavy cloud cover. A substantial amount of research now is being carried out in Canada to develop ways to conserve energy in greenhouses. In addition, other research not directly connected to greenhouse energy needs will make a technology contribution by making overall production more efficient.

It is not practical to heat an inefficient greenhouse principally with solar heat. Conventional greenhouses do not have enough surface area to collect sufficient energy. Additional solar collectors would be needed and an excessively large heat storage area. Obviously this will require additional land area as well as funds. Conservation techniques must first be fully exploited if solar energy is to be able to make a meaningful contribution to greenhouse energy costs.

High energy costs have stimulated experiments using sun and wind.

When a greenhouse makes efficient use of heat, such as using insulating curtains, etc., the heating load drops so much that the solar component is no longer cost effective. The heat storage or backup systems add costs that usually make the modified system too expensive. Many solar collectors available today cost more per square meter than the cost of the greenhouse, including installation of the heating system.

Agriculture Canada specialists have determined that solar heating will most likely have a place in the greenhouse industry only if it is an integral component of the building design.

The Brace greenhouse is a solar type of structure that was developed in Canada. It is very energy efficient but is not compatible with traditional, commercial greenhouse management techniques. It has an insulated north wall, heat storage beneath or inside the structure and a large south-sloping face as the solar collector.

Agriculture Canada is participating in several projects aimed at making the Brace system more suitable for commercial crop production. An evaluation project also is underway at the federal department's research station at Vineland, Ont., into a low-cost solar greenhouse using inflatable solar collectors. The collectors are detached from the greenhouse itself, and a porous concrete floor in the growing area acts as a heat ex-

change and storage unit. This system, developed at Rutgers University in the United States, appears to have economic merit, but its ability to function properly in a country in a northern latitude such as Canada will remain a question until evaluation is complete.

Another research project at the University of Saskatchewan is developing a solar-type greenhouse, with major emphasis on practical energy conservation techniques. Other projects involving energy and greenhouses that are being carried out across Canada include the development of affordable solar units, including small models that could attach to a residence.

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HIGH-PROTEIN WHEAT — PRODUCTION AND USE

S. DUBETZ and
E.E. GARDINER

On peut produire du blé fortement protéiné (22% environ) en fournissant passablement d'azote au sol et en contrôlant l'irrigation.

Le blé fortement protéiné additionné de Lysine peut remplacer jusqu'à la moitié des repas de fèves soja dans le régime de la volaille. Les éleveurs de volailles pourraient trouver économique de remplacer les fèves soja, produit importé relativement cher, par du blé protéiné cultivé au Canada.

Wheat protein content varies with cultivar and is influenced by climate and soil. The principal climatic factors are rainfall and temperature. Protein content tends to be higher in wheat grown in hot dry climates than for wheat grown in cool moist climates. The main soil fertility factor is nitrogen (N). When nitrogen is available in relatively large amounts, the protein content of the seed increases. The main soil physical factor is soil water. When soil water availability is low, particularly during the later part of the growing season, grain protein content is high.

Experiments conducted on irrigated land have shown that the protein content of hard spring wheat (cv. Neepawa) can be increased 50% or more through the application of relatively large amounts of N fertilizers. Some typical results are shown in Figure 1.

Additions of N fertilizer resulted in large responses in yield and protein in fields A and B, whereas there was no response in field C. The soil in the first two fields was silt loam and contained 15 and 23 ppm available N in the top 30 cm of the profile. Field C was a clay loam and contained 52 ppm of available N. Field C had a relatively high water-holding capacity and the crop was not as likely to be subjected to a moisture stress during the growing season as it would on field A or B. Equally, the available N content to the 30-cm depth was

high (and this was probably also true for the lower depths), therefore, the crop was not as likely to respond to fertilizer N on field C as it was on fields A and B.

The first 200 kg of N/ha increased yields 120% on field A and 48% on field B, and increased protein 44% on field A and 57% on field B. Further increases in yield or protein from the second 200-kg increment were only 5-12%.

N fertilizer is usually applied to the soil at planting time. It is possible to apply N as a spray of urea solution at the plant flowering stage. In one experiment, yields were not increased because tillering had already taken place and head size established, but protein content increased from 14.0 to 18.8% when 50 kg N/ha was used. Efficient use of N for increasing protein can probably be achieved with this method by metering fertilizer through a sprinkler system.

Protein content can also be increased by subjecting the plants to a soil water stress at the heading or flowering stages. This can be achieved by withholding irrigation. Yield decreases, dependent on the severity of the stress, can also occur due to shrunken kernels. It is possible, however, to manipulate N fertilizer rates and irrigation in such a way as to maximize yield and protein production. Some experimental plots have produced wheat with a protein content of 22% (oven-dry basis). The specific management required will be determined by the soil type and its fertility, the value of the crop and its protein content, and the cost of fertilizer. Because the costs for producing high-protein wheat are high, farmers will have to be paid for their crop on the basis of protein content.

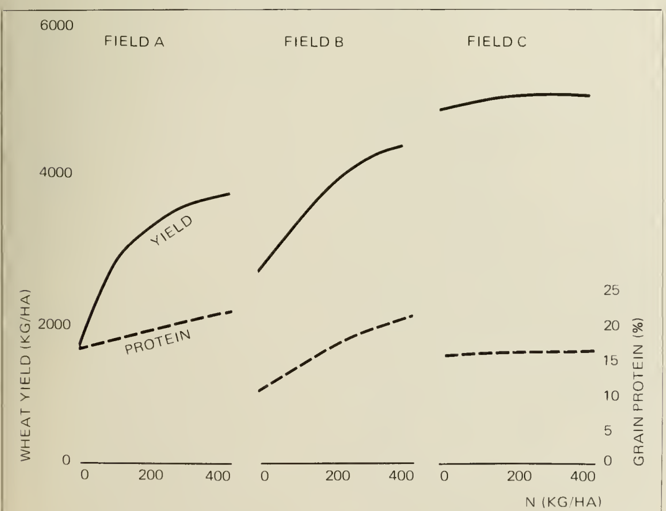


Figure 1. Yield and protein responses of spring wheat to N fertilizer.

For milling purposes, it is not necessary (perhaps even detrimental) to use wheat that contains more than 18% protein (13.5% moisture basis). However, because considerable quantities of wheat are used in poultry feeds, the role of high-protein wheats in poultry nutrition has been established for broiler chicks, turkey poults, and laying hens.

Male broiler chicks were fed diets containing 14.5%- and 21.0%-protein Neepawa wheat from 1 to 28 days of age. The desired 22% dietary protein contents were obtained by varying the proportions of the wheats and soybean meal.

The high-protein wheat supplemented with 0.24 or 0.30% lysine supported body weights and resulted in feed-to-gain ratios of chicks that were not significantly different from those fed the 14.5%-protein wheat diets (Table 1). The high-protein wheat diets, however, contained 60% less soybean meal than the 14.5-protein wheat diets.

An experiment similar to the one with chicks was conducted with

TABLE 1. MEAN BODY WEIGHTS (GRAMS AT 28 DAYS) AND FEED-TO-GRAIN RATIOS OF MALE BROILER CHICKS FED DIETS CONTAINING TWO NEEPAWA WHEATS OF DIFFERENT PROTEIN CONTENT

Wheat protein	Added lysine (%)					
(%)	0.00	0.06	0.12	0.18	0.24	0.30
			Body weight (g)			
14.5	698	676	663	653	663	662
21.0	323	414	488	533	610	627
			Feed-to-gain ratio			
14.5	1.63	1.60	1.56	1.57	1.66	1.55
21.0	1.89	1.84	1.81	1.77	1.73	1.62

Research on high protein wheat is also carried out at the Brandon Research Station.

turkey poults (Table 2). Turkey poults have a higher protein requirement (about 28%) than chicks. The 14.5%-protein wheat diets, which contained relatively high proportions of soybean meal, supported rapid gains and did not respond to lysine supplementation. The 21.0%-protein wheat diets, when supplemented with at least 0.2% of lysine, supported as rapid gains as the 14.5%-protein wheat diets.

Because laying hens require about 16% protein in their diet, diets that were formulated with high-protein wheat contained no soybean meal.

TABLE 2 MEAN BODY WEIGHTS (GRAMS AT 28 DAYS) OF MALE TURKEY POULTS FED ON DIETS CONTAINING TWO NEEPAWA WHEATS, SUPPLEMENTED WITH LYSINE

Wheat protein	Added lysine (%)					
(%)	0.0	0.1	0.2	0.3	0.4	0.5
14 5	881	914	890	910	862	899
21.0	739	841	864	869	836	852

TABLE 3. EFFECT OF CONVENTIONAL WHEAT AND HIGH-PROTEIN WHEAT DIETS WITH VARIOUS LEVELS OF LYSINE ON THE PERFORMANCE OF WHITE LEGHORNS

	Conventional wheat		High-protein wheat				
	1	2	3	4	5	6	7
Added lysine (%)	0.0	0.3	0.0	0.1	0.2	0.3	0.4
Egg production (%)	82.9	79.9	65.3	78.7	81.5	80.3	80.2
Egg weight (g)	55.2	55.6	51.6	53.9	54.0	55.2	55.7
Food conversion (kg/12 eggs)	1.63	1.76	1.97	1.87	1.78	1.85	1.83
Mortality (%)	10.0	5.0	10.0	0.0	5.0	5.0	5.0
Food intake (g/bird-day)	110	109	108	122	120	116	120

Production and weight of eggs from hens fed the unsupplemented high-protein wheat diet (Table 3) were significantly lower than those from hens fed the other diets. However, when the high-protein wheat diets were supplemented with lysine, egg production and egg weights were not significantly different from those of birds fed the conventional wheat diets. Mortality, specific gravity, and egg shell strength were not affected significantly by diet.

High-protein wheat (about 22%) can be produced by ensuring a relatively large supply of nitrogen in the soil and, where applicable, by manipulating irrigation. Because the costs of producing high-protein wheat are high, farmers should be paid for their crop on the basis of protein content.

High-protein wheats supplemented with lysine can replace more than half of the soybean meal in diets fed to broiler chicks, and more than one-third in diets fed to turkey poults. When supplemented with lysine, high-protein wheats can be fed to Leghorn hens without any soybean meal. Wheat is lower in lysine than soybean meal, therefore, when high-protein wheats replace some or all of the soybean meal the diets must be supplemented with lysine.

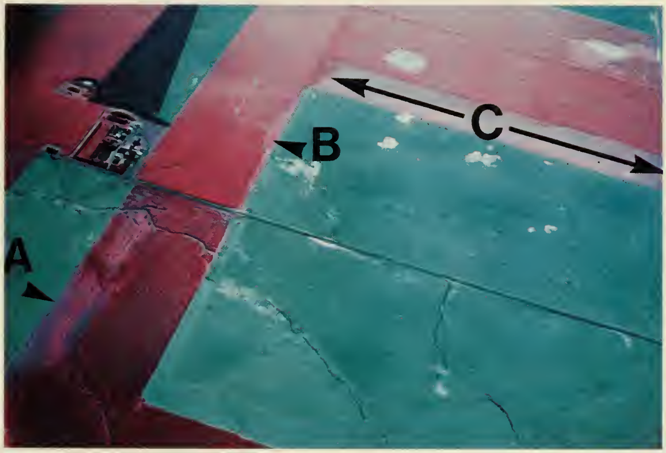
Canada imported 350,000 tonnes of soybean meal in 1977. The economics of using high-protein wheat in poultry diets depends largely on the relative prices of the wheat and soybean meal. The price of soybean meal can fluctuate widely in some years and, when it is relatively high, poultry producers can benefit from using high-protein wheat. A detailed economic study of the precise role of high-protein wheats for poultry diets is now underway.

S. Dubetz and E. E. Gradiner are research scientists at the Lethbridge Research Station, Lethbridge, Alberta.

ASSESSING CEREAL CROP GRASSHOPPER DAMAGE USING INFRA-RED PHOTOGRAPHY

O.O. OLFERT and
M.K. MUKERJI

On met au point au Saskatchewan un outil de gestion qui s'appuie sur des principes écologiques et économiques afin de protéger les cultures de céréales contre les dommages causés par les sauterelles. La photographie aérienne à l'infrarouge est la plateforme de ce système de gestion et s'appuie sur des estimations réelles des pertes de cultures dues aux sauterelles.



Aerial infra-red photograph depicting grasshopper damage.

The threat of grasshoppers to Prairie cereal production was recognized when agriculture was first initiated in the Canadian West. Since then, prairie farmers have had to combat numerous local and widespread grasshopper infestations. Various factors influence decisions made by farmers on required crop protection measures. Adequate research and extension programs can improve the information base for making decisions. Therefore, a management system based on ecological and economic principles is being developed in Saskatchewan to be used in the protection of crops from grasshopper infestations.

An integral part of the management system is the precise quantification of yield loss of cereal crops due to grasshoppers. Since defoliation by grasshoppers alters the crop canopy, aerial photography by infra-red films can be an efficient tool in assessing crop loss. The interpretation of infra-red aerial photographs involves four major steps:

- identification of cereal crops,
- identification of crop defoliation by grasshoppers,
- measurement of an area with or without defoliation and
- estimation of crop yield.

Correct identification of a crop species must be made to assess the effect of grasshopper defoliation on the crop.

Equidensitometry or the technique of density slicing is used to identify crop species. By this technique the optical density range of an aerial photograph can be subdivided into a number of intervals. Thus the optical density value of each image point is replaced by the value of the slice into which it falls. At present, 95% accuracy is obtainable in differentiating spring wheat from durum. In general, spring wheat falls into lighter, while durum falls into the darker density levels. As the density slices of barley and oats overlap severely with durum wheat, and those of oilseeds overlap each other, equidensitometry is not a good technique to identify barley and oats or to differentiate oilseeds from each other. However, grasshoppers are most abundant in southwestern Saskatchewan where wheat accounts for more than 90% of the seeded crop land. Therefore, the task of identifying crops is a matter of differentiating between the two wheat species.

A dichotomous key has been designed to distinguish defoliation of crops by grasshoppers (Figure 1) from other anomalies, such as erosion, salinity, etc. (Figure 2). From aerial photographs, and verified with ground observations, the key compares characteristics of each of the anomalies with grasshopper damage. This key takes into account three major types of grasshopper damage to crops; defoliation along a field margin; continuous defoliation from the margin

DR. OLFERT and DR. MUKERJI examining infra-red photographs of an aerial survey of grasshopper damage.

across a major portion of the field; and defoliation within a field.

Measurement of an area of a crop, whether or not damaged by grasshoppers, is accomplished by the use of a planimeter from representative aerial photographs enlarged to a suitable scale. The perimeter of the damaged area is identified, measured, and the area is expressed as a percentage of the total area of the field.

The procedure to estimate crop yield involves two steps (Figure 3): Biomass estimates are obtained from a linear relationship between optical density of the aerial photograph and wheat biomass attained during 830 – 860 degree-days ($> 5.6°C$) after seeding; subsequently yield is estimated from another relationship between wheat yield and biomass during the same time frame. These relationships hold good for a different year if availability of soil moisture is taken into account. Thus the optimum time to estimate wheat

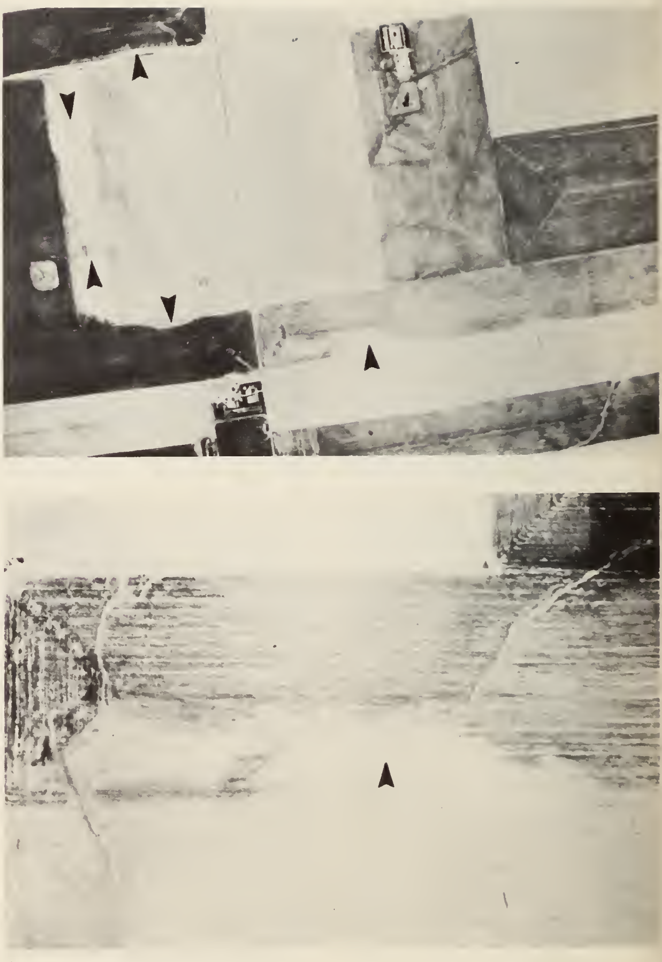


Fig. 1 Aerial photographs showing extensive grasshopper damage (indicated by arrows) to wheat crops in Saskatchewan.

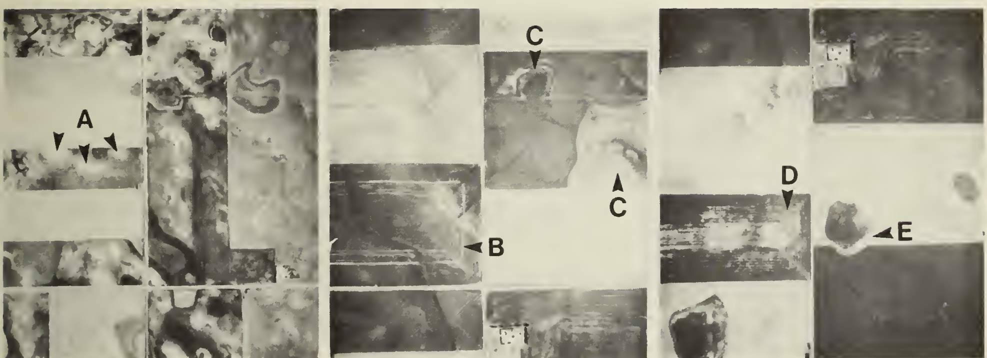


Fig. 2 Aerial photographs showing identifiable anomalies other than grasshopper defoliation: A – dry, eroded areas; B – faulty seeding; C – slough; D – poor germination; E – alkali soil.

DENSITOMETER	→	CROP BIOMASS	→	CROP YIELD
OPTICAL DENSITY OF AERIAL FILM		STANDING CROP BIOMASS/UNIT AREA		YIELD OF GRAIN AT HARVEST

Fig. 3 Steps involved in estimating yields of cereal crops from aerial infra-red photographs.

yield from aerial photographs is approximately between 800 - 850 degree-days after seeding.

Our studies show that the technique of aerial infra-red photography for estimating reduction in wheat yield due to grasshoppers has distinct advantages over a ground survey: the costs of an aerial assessment are 10% of a similar ground survey; estimates of yield loss made from aerial survey are more precise than those obtained from ground survey; aerial survey of an area can be completed in less than half of the total time required to survey a similar area on the ground.

Drs. Olfert and Mukerji are insect ecologists at the Agriculture Canada Research Station, Saskatoon, Sask.

WIREWORMS IN BRITISH COLUMBIA

A.T.S. WILKINSON

On a réussi à maîtriser les taupins en Colombie-Britannique grâce à l'utilisation des insecticides Aldrin et Heptachlor dans le sol. Cependant, à cause de leur persistance dans le sol où ils sont absorbés par les plantes puis transmis en quantité non-acceptable dans la viande et le lait, on en a banni l'utilisation en 1963. Les recherches pour trouver des insecticides de rechange n'ont pas donné les résultats escomptés. Fonofos est le seul insecticide recommandé pour le contrôle des taupins mais c'est un insecticide dont l'application est coûteuse, ne dure qu'un an et dont l'efficacité n'est pas garantie. Depuis 1963, les populations de taupins se sont accrues en Colombie-Britannique et causent de plus en plus de dommages aux récoltes.

A wireworm.

A click beetle is the adult stage of a wireworm.

Wireworms have been damaging vegetable, grain and potato crops in British Columbia more and more each year. The greatest losses are in corn and potato crops in the lower Fraser Valley. Six species of native wireworms and two introduced from Europe cause most of the damage. Before 1950 the only way wireworms could be restrained was by cultivating and rotating crops. These measures gave mediocre control and losses were heavy. At that time wireworms were one of the major problems confronting vegetable growers and wheat farmers. Crops susceptible to wireworm damage such as potatoes and corn could not be grown in heavily infested land.

Two very effective soil insecticides, Aldrin and Heptachlor, became available in the early 1950s and temporarily solved the wireworm problem. Between 1953 and 1963, insecticides were incorpor-

ated into most of the infested land and were also applied to many more hectares without a history of wireworms as insurance against possible infestation. Because of the use of these chemicals, wireworms quickly became only a minor problem.

These insecticides gave not only immediate but also long-term control. Bioassays with young wireworms from soil treated with aldrin or heptachlor showed that a single treatment with either chemical continued to kill young wireworms for 13 years. Crops would be safe for several more years because of the time required for wireworms to reinfest large treated areas from surrounding untreated areas. The adults of the two European wireworms do not fly so it would take even longer for them to re-enter a field where good control had been obtained. One field treated at Agassiz in 1953 was found to be heavily infested in 1978, 25 years later, when 17 acres of corn were destroyed.

Aldrin and heptachlor were banned in 1963 because of their persistence in the soil and because they were taken up by plants, resulting in accumulation of intolerable chemical levels in meat and milk. Many new insecticides and several application methods have been tested in searching for replacements for the banned insecticides. None has given the excellent control previously achieved. Hence, reinfestation of land treated with Aldrin or Heptachlor over 15 years ago is increasing at an alarming rate.

Fonofos is the only insecticide that is currently recommended for wireworm control in British Columbia. It has given good control under some conditions but has often

A field of corn badly damaged by wireworms.

Potato with wireworm feeding tunnels and an undamaged potato.

failed to produce an acceptable control level in peat and muck soils or in heavy infestations. The cost of a broadcast treatment of fonofos is about $125 a hectare for material alone. This high cost would be acceptable to the grower only if the treatment were more reliable. In some cases the cost can be reduced by applying fonofos at half the broadcast rate in the furrow with the seed or as a side dressing. These application methods increase the concentration of insecticide right at the area where short-term protection is needed, but they do not effectively reduce a field's total wireworm population. At one time a wireworm control was available that was inexpensive and was effective for up to 20 years. Now reliance must be placed on a treatment that is expensive and must be applied each time a susceptible crop is planted in land infested with wireworms.

Although the numbers of our native wireworms have been increasing recently, it is the introduced European wireworm, *Agriotes obscurus* (L.), that is causing the most concern in the lower Fraser Valley. This species builds up to very high populations and is spreading. It was originally found in 1952, severely damaging corn in the Agassiz area. Several other infestations have been found since, the most important one about 70 km west of Agassiz near Cloverdale, where potatoes and corn were severely damaged. In the past four years this wireworm species has been found on ten farms in this new area, distributed over 3 200 hectares. Twenty-five to 70% of the potatoes from these infested fields are unmarketable for table use.

The Agassiz infestation is believed to have been established for about 50 years before being discovered. The distribution and the number of wireworms at Cloverdale indicates that this infestation was also present for some time before discovery. There are probably many other infestations in the lower Fraser Valley that will become evident as the numbers of wireworms increase.

The other introduced wireworm, *Agriotes lineatus* (L.), is a potato pest near Duncan on Vancouver Island, and has recently been found in a backyard garden in Vancouver. It is a potential threat since it would cause considerable crop damage if it spread into the farmland in the lower Fraser Valley.

Man was responsible for introducing these European wireworms into British Columbia and he continues to spread them, primarily by moving equipment and materials from one field to another and from one community to another. Little can be done to stop this spread. Since good control strategies that are effective under all conditions are not available, wireworms are once again a problem for agriculture in British Columbia.

Mr. Wilkinson is an entomologist, Agriculture Canada Research Station, Vancouver, British Columbia.

MÉLANGES CÉRÉALIERS ET MALADIES

L. COUTURE

Mixed grains culture is popular in eastern Canada where yields of components (oats and barley) in mixture are different of those obtained in pure culture. This difference is connected with the relative competition of species involved but also with the lower development of fungal diseases in cereals grown in mixture, for example, net blotch of barley.

La culture de mélanges céréaliers, appelés parfois "gaudrioles" par nos ancêtres, connaît toujours une grande faveur chez les agriculteurs de l'est du Canada. Les statistiques les plus récentes (1977), montrent que les champs de céréales en mélange occupent 31% des superficies cultivées en céréales à paille dans l'est contre à peine 1% dans l'ouest canadien. Cette différence entre les deux grandes régions s'explique par la production massive de céréales pour l'exportation dans l'Ouest, par rapport à une production de grains pour consommation à la ferme dans l'Est.

Ce choix de l'Est ne peut être attribué aux recommandations officielles de grandes cultures, puisqu'aucun avis spécifique n'est formulé à ce sujet dans les guides de productions végétales couramment disponibles. Ce sont des facteurs d'ordre pratique qui interviennent pour expliquer la préférence manifestée par les adeptes de cette forme de culture, notamment la tendance de ces mélanges à donner des rendements supérieurs à ceux qui pourraient être obtenus isolément en monoculture, à densité de semis égale. En outre, la récolte de céréales mélangées se prête à la préparation de rations généralement mieux équilibrées pour le bétail et la volaille.

A la station de recherche d'Agriculture Canada à Sainte-Foy, on s'intéresse à l'effet des mélanges sur le développement des maladies des céréales cultivées en association, ainsi que sur les rendements correspondants obtenus. On a donc établi des parcelles expérimentales à la ferme d'Agriculture Canada à La Pocatière au printemps de 1978. On a mélangé l'orge Loyola et l'avoine Alma en différentes proportions en plus de les semer séparément en culture pure. A la fin de la saison, on a récolté le grain des parcelles et les résultats de rendement en orge et en avoine sont présentés à la figure 1. Le rendement réel en grains (partie foncée) d'une espèce dans un mélange a été ramené sur une base de semis pur (colonne entière), afin de pouvoir comparer directement la capacité de rendement d'un mélange à l'autre.

Ainsi, l'on constate que l'orge a présenté un optimum de rendement dans un mélange à 50% tandis que la dilution progressive de l'avoine de 100% à 2% était ac-

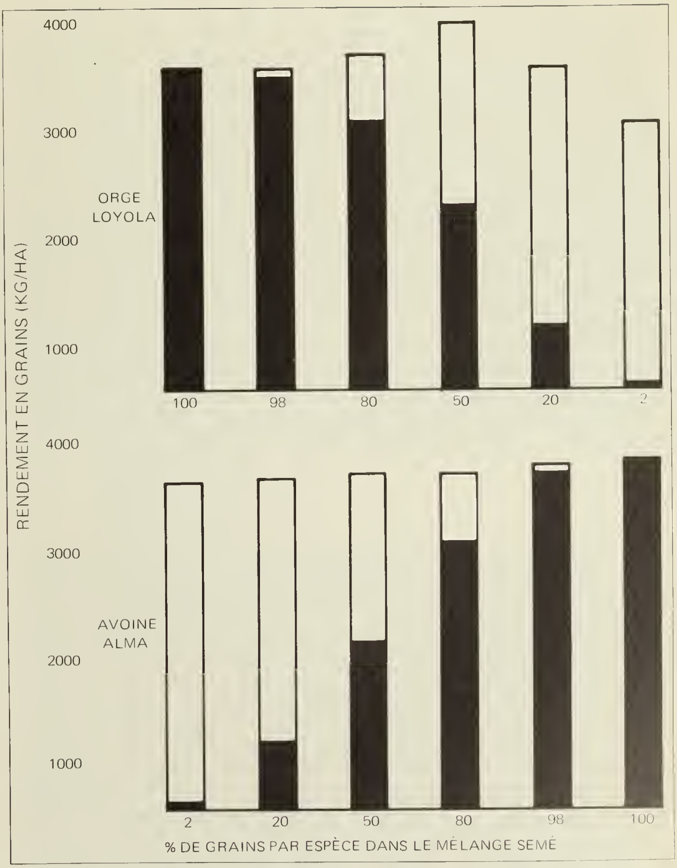


Figure 1. Rendement en grains d'une orge et d'une avoine cultivées en cinq mélanges ou en monoculture. La colonne entière désigne la productivité théorique d'une espèce dans un mélange donné, obtenue par conversion du rendement réel mesuré (partie foncée) de cette espèce sur une base de semis pur (100%).

compagnée d'un minime fléchissement du rendement.

Ces résultats reflètent une plus grande aggressivité de l'orge en compétition avec l'avoine. Mais il y a plus que cela. Dans les mêmes parcelles nous avons procédé à la notation de l'intensité des maladies du feuillage de l'orge et de l'avoine. Il s'est développé très peu de tache septorienne de l'avoine cette saison-là à La Pocatière, si bien que l'on ne distinguait pas de différence entre les mélanges à cet égard. Par contre la rayure réticulée de l'orge causée par le *Drechslera teres* s'est développée de façon plus intensive. Voici les résultats d'observations relevées dans les différents mélanges au stade de développement pâteux du grain, sur la feuille pénultième de l'orge:

Proportion d'orge dans le mélange (%)	Intensité de la rayure réticulée (%)
100	23
98	23
80	14
50	13
20	9
2	3

On constate que l'intensité de rayure réticulée diminue beaucoup avec la dilution de l'orge par l'avoine. Nous avions noté des différences décroissantes analogues dans une étude réalisée en Ontario sur une autre maladie de l'orge, la tache helminthosporienne (bipolariose), causée par le *Bipolaris sorokiniana*. C'est donc dire que la dilution d'une espèce cultivée en mélange, produit des effets bénéfiques du point de vue phytosanitaire.

Voici l'explication de ce phénomène. La plupart des maladies fongiques qui affectent les feuilles de l'orge n'attaquent pas les feuilles de l'avoine et vice-versa. Ainsi, la multiplication de spores d'un champignon pathogène sur une plante d'avoine n'affecte pas les plantes d'orge qui se dressent autour d'elle. Simultanément, les plantes d'avoine nuisent à la dispersion efficace des spores d'une plante d'orge à l'autre en s'interposant entre elles. La maladie se propage donc moins rapidement. Il en résulte une intensité de maladie moindre de ce qu'elle serait chez la céréale pure. Il va sans dire que l'effet mentionné est réciproque aux deux espèces en mélange.

Symptômes de la rayure réticulée de l'orge.

Mélange de grains d'avoine et d'orge

Comme les maladies des céréales abaissent le rendement en grain à cause du déverdissement qu'elles provoquent sur les feuilles, le résultat de la diminution de l'intensité des maladies se répercute sur le rendement.

A l'heure actuelle les caractéristiques de hauteur et de précocité des cultivars de céréales recommandés, coïncident plus ou moins bien d'une espèce à l'autre. Mais il est probable que l'addition régulière de nouveaux cultivars homologués par Agriculture Canada pourra permettre une flexibilité dans le choix des partenaires d'un mélange. De notre côté, nous poursuivons présentement nos recherches sur cette question pour obtenir des données plus complètes et précises sur l'évolution des maladies fongiques dans les mélanges céréaliers, et voir la proportion optimale des deux espèces qui les composent.

Luc Couture est pathologiste des céréales à la Station de recherche d'Agriculture Canada à Sainte-Foy (Québec).

VERTICILLIUM WILT OF ALFALFA

H. MARKELL

La flétrissure verticilienne, récemment introduite en Amérique du nord, est la plus dommageable des maladies de la luzerne. On décrit ici la nature de cette maladie ainsi que les principaux moyens de la combattre, y compris la recherche de variétés résistantes. Le traitement obligatoire pour la campagne de 1979-1980 fait également l'objet d'une description.

Verticillium wilt is considered the most important and the most damaging of all alfalfa diseases and, until recently, it was relatively unknown in North America.

The disease is introduced into new areas with contaminated seed. "It is not usually carried on or in the seed itself, but by infested plant debris that pass through the harvesting process with the seed," explains J.W. Sheppard, Seed Biologist with the Seed Biology Laboratory of Agriculture Canada.

Under favorable conditions, the fungus grows from the debris into the soil, and then enters the plant through the roots. Once inside, it plugs the vascular system and cuts off the flow of nutrients from the roots. The fungus forms substances which cause a brown staining of the vascular vessels; this discoloration can often be traced from the small lateral roots to the leaf tips at the top of the plant. Plants may be stunted.

Early symptoms of the disease include wilting of the plant, with drooping of the tips in the heat of the day. Chlorosis begins on the lower leaves and progresses up the stem, and later becomes general, until all the leaves are necrotic. Severe infection ends in defoliation. Often only one shoot is affected and new shoots frequent-

Alfalfa field near Creston, B.C. heavily infested with verticillium wilt. Photo by Bob France.

Stunting and chlorasis caused by verticillium wilt in thor alfalfa near Keremos, B.C. Photo by J. Sheppard.

ly grow from the base of infected plants. Occasionally, the base of dead stems become darkened and have a dull greyish appearance, caused by the production of spores on the surface.

Secondary spread occurs by contact of spores or transported fragments of diseased material with stems of plants cut during harvest. Severity of the disease varies from minor damage to complete destruction. Fields have become unproductive after three years, and must be plowed down.

In January, 1979, alfalfa seed lots being imported from the United States showed a high incidence of *Verticillium albo-atrum*, the organism that causes the Verticillium wilt disease. Since then, the disease has been found to be widespread in British Columbia, where reduction in longevity of alfalfa stands from six years to three years has been reported. The organism has also been isolated from alfalfa seed produced in other provinces.

"The appearance of the disease in Canadian fields is alarming, because it shows that it can survive and develop under Canadian conditions," says Mr. Sheppard. The disease could have been present at a low level for many years as symptoms resemble those of other alfalfa disorders.

The best means of controlling this disease is through the use of resistant varieties of alfalfa. However, until now, Canadian cultivars have not been bred specifically for resistance. Research is underway to screen all licensed varieties for resistance, thus enabling farmers to choose those best adapted to their areas. Efforts are also being made to incorporate the resistance of many European cultivars into present breeding programs. It may take several years before these programs become effective.

Until then, the best means of control is through good management and the use of seed treatment with a recommended fungicide, such as Thiram. Seed treatment will protect new seedlings from infected debris and prevent introduction of the disease into previously uninfected fields.

Spread of the disease by contaminated machinery can be reduced by cutting healthy fields first and by disinfecting equipment. Of benefit also is the use of non-susceptible crops, such as grasses and cereals, in rotation with alfalfa.

"Most recent evidence shows that the harmful effects of Thiram on alfalfa rhizobia are minimal, and that nodulation and crop yields are not affected when the rhizobia are applied to the seed at planting time," says Yudi Singh, Head of Seed Standards at Agriculture Canada.

Effective immediately in Canada, before sale all alfalfa seed, domestic or imported, must be treated with Thiram at the rate of four ounces of active ingredient per 100 pounds of seed.

"There are several formulations of Thiram presently registered in Canada and suppliers should be urged to use these where possible," says Dr. Singh. For the 1979-80 season, any formulation of Thiram recommended by the exporting countries for treatment of alfalfa would be acceptable. However, imported seed treated with Thiram formulations not registered in Canada will be monitored for possible toxic effects. Foreign suppliers should have their formulations registered.

Imported alfalfa seed must be accompanied by a certificate indicating that it has been treated as required. Untreated seed will be allowed entry to Canada for treatment prior to sale. Carryover seed or seed mixtures containing alfalfa will be exempt from mandatory treatment, but must be labelled "Agriculture Canada recommends that this seed be treated with a fungicide registered for the control of Verticillium wilt. (For advice, see your local Agriculture Representative.)"

There are other special situations. Alfalfa seed for production of sprouts for human consumption is exempt from treatment, provided the importer can prove that it will be used only for this purpose. Pelleted or coated seed may have the treatment applied to the seed or coating material. It is exempt from the staining requirements under the Seeds Regulations, but must be labelled as required for treated seed.

Analytical results on purity and germination from laboratories in the United States will be accepted on importation into Canada, provided that adequate sampling has been done and proper certification attached.

Verticillium wilt must be controlled. Further establishment of the disease in the alfalfa-producing areas of Canada could cause severe economic losses for hay producers and for cattlemen who use the crop to feed their cattle.

Mr. Markell is an information officer with Agriculture Canada, Information Services, Ottawa

RAINFALL DISTRIBUTION AND POTATO PRODUCTION IN NEW BRUNSWICK

G.R. SAINI and T.L. CHOW

Il est rare que l'on fournisse une irrigation supplémentaire dans la culture de la pomme de terre, que ce soit au Canada ou ailleurs dans le monde. A la station de recherche de Fredericton, on a mené une étude préliminaire afin de déterminer si l'on doit poursuivre les recherches dans ce domaine. On a observé une différence marquée dans la production, selon le moment et la quantité de pluie tombée à différentes étapes de la croissance, malgré une abondance de pluie relativement constante durant l'année.

To assess the need for research on potato irrigation in New Brunswick, rainfall data recorded by the Environment Atmospheric Service of Canada for 1949-75 in the potato growing area of the province were examined and compared with crop yield data available from the New Brunswick Department of Agriculture. These data (Table 1) reveal that tuber yields seem to have no relationship with total rainfall during the crop's growing period (June 1 to September 30). For example, in 1952, 1957, 1960 and 1971, rainfall during the growing period was about 330 mm, but marketable tuber yields were 17.3 tonnes/ha (1952), 22.3 (1957), 19.5 (1960) and 26.3 (1971). The correlation coefficient (r) between the two sets of figures for the 1949-75 period was -0.35; this is nonsignificant. Multiple correlation between the rainfall when separated by month and tuber yield was also nonsignificant (R- 0.46).

To better understand the soil-water relationship in New Brunswick potato production, daily rainfall from June 1 to September 30 for each year of the 1949-75 period was grouped into 12 - 13 day intervals. Each interval was designated as an independent variable. Stepwise regression analysis of the 10 independent variables was performed using yield as the dependent variable.

The average rainfall was uniformly distributed throughout the growing period, except for the early two periods in June and the late two periods in September, which were less than those from late June to early September. The stepwise regression analysis yielded the following equation:

$Y = 22.23 - .04X_1\ .06X_4 - .04X_9$, where Y is the yield in tonnes/ha, X_1 the rainfall in mm during June 1-12, X_4 the rainfall in mm during July 13-24 and X_9 the rainfall in mm during September 7-18. The regression equation has a multiple correlation coefficient of 0.59.

Table 1

Year	Rainfall June 1-Sept. 30 (mm)	Marketable tuber yield tonnes/ha
1949	380.9	20.6
1950	336.9	19.2
1951	464.9	16.8
1952	341.8	17.3
1953	417.8	19.4
1954	613.4	14.9
1955	369.4	22.2
1956	320.7	22.2
1957	338.1	22.3
1958	485.4	19.6
1959	374.7	19.1
1960	335.1	19.5
1961	477.2	21.1
1962	435.0	24.0
1963	469.5	22.9
1964	297.7	24.1
1965	370.3	22.2
1966	281.8	25.0
1967	431.1	22.8
1968	238.8	25.3
1969	508.0	23.1
1970	357.8	24.1
1971	320.5	26.3
1972	535.2	25.7
1973	404.4	21.7
1974	405.7	25.9
1975	383.5	20.7

Addition of the remaining seven independent variables did not make a significant contribution to the regression equation.

Although the correlation coefficient of the regression between potato yield and rainfall periods is low, it must be recognized that crop yields are dependent upon several factors — the soil on which they are grown, the climate, management techniques and the crop itself. Furthermore, each of these factors has several components and, in this instance, only one component, climate, was considered in the regression equation.

The negative values of the regression coefficients of X_1 and X_9 in the above equation, based on the rainfall data for 27 years, indicate that heavy rainfall during most of June, when the plants are young, or in the latter part of September, when they are almost mature, is harmful since the plants are incapable of using the surplus water in the soil.

The results also indicate that rainfall during the periods X_1, X_4 and X_9 are quite variable and that yield varies with these variables. From the positive value of regression coefficient for X_4, it is also reasonable to speculate that irrigation in that period, i.e., about the later half of July, might be beneficial for potato production. From these preliminary observations, it is recognized that more research and refinement of the model are needed if any prediction of irrigation time is desired. Further work is continuing at the Agriculture Canada Research Station, Fredericton.

Dr. Siani is a soil physicist and Dr Chow is a hydrologist at the Agriculture Canada Research Station, Fredericton, New Brunswick

TEST TUBE PROPAGATION OF APPLE AND PEAR

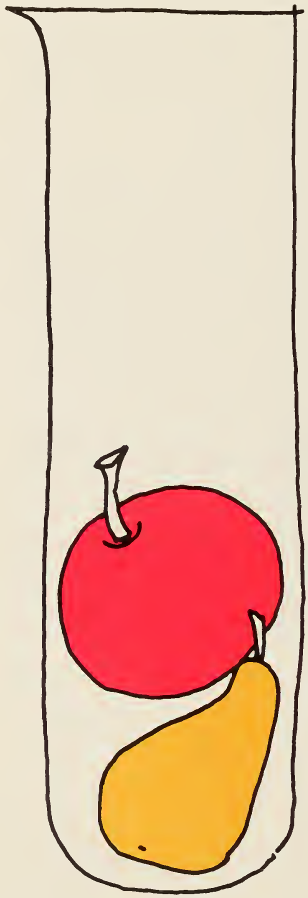
W. D. LANE

A la station de recherche d'Agriculture Canada à Summerland, C.-B., on est à mettre au point des techniques de culture des tissus en vue de la propagation rapide des poiriers et des pommiers. C'est une méthode simple, déjà mise en application pour les plantes tropicales. A cause de la forte demande de stocks, cette méthode pourra bientôt être utilisée commercialement pour les arbres fruitiers.

Tissue culture techniques being developed at the Summerland Research Station appear feasible for rapid propagation of apple and pear trees and should soon be ready for commercial use.

Traditional fruit tree propagation involves growing rootstocks in stoolbeds (which require four to six years to reach full production), grafting the desired cultivar onto the rootstock, and growing this two-part tree for two years until ready for orchard planting. This procedure is slow and difficult to adjust to changing needs. A faster method of propagating fruit trees is needed because of increased demand for fruit trees created by favorable prices, denser plantings and changing cultivar preferences. Application of the new tissue culture technique should satisfy this need.

The technique is relatively simple and is currently being used commercially with many easy to propagate tropical foliage plants such as boston fern. A sequence of steps is involved. Small shoot- or meristem- tips are grown aseptically on nutrient media. After initiation of growth, proliferating mother cultures produce shoots which are then rooted in a second medium. The mother culture regenerates



new shoots from the stump after transfer to fresh medium. Rooted shoots are hardened off then treated like normal plants.

Our apple and pear cultures are started from either dormant or actively growing vegetative buds. After removal of outer leaves and bark from the shoot-tip, microorganisms are killed by soaking the tips in commercial bleach diluted with 6 parts water. After rinsing they are placed in test tubes on a growth medium containing macro and micro mineral nutrients, several vitamins, 3% sucrose and a plant growth regulating chemical. The medium is gelled with agar to support the plant tissue which at the beginning of culture is only 1 mm long.

The test tube cultures, and also larger shoot producing cultures grown in 200 ml jars, are incubated in a growth room with high light intensity and controlled temperature and day length. Growth of the cultures is not dependent on photosynthesis as the sucrose is used for energy.

The growth regulator in the medium is a cytokinin (benzyladenine) which functions in this system to stimulate shoot growth from the bud in the axil of each leaf. As the tissue culture develops, shoots proliferate, forming a multiple shoot structure like a "witches broom". The concentration of benzyladenine is critical. If it is too high, every bud grows resulting in a tight cluster with many very short shoots. If it is too low only a portion of buds develop and these become long in the absence of competition from other shoots. The optimum benzyladenine concentration gives the maximum number of shoots that are long enough to be easily cut

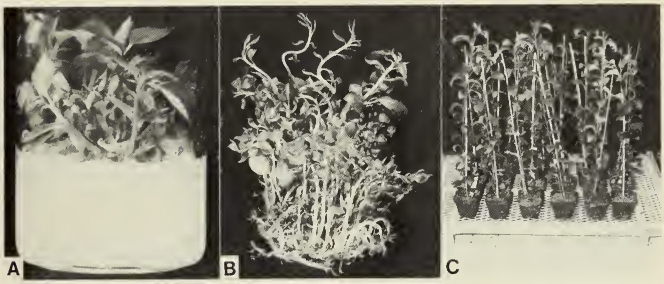
from the mother culture and transferred to the rooting medium. Each apple culture produces about 20 shoots every 3 weeks, pears about 50 every month. These cultures, if properly maintained, continue to produce for years.

Shoots about 2 cm long, taken from the multiple shoot culture, are rooted in a medium with a root initiating auxin (naphthaleneacetic acid) replacing the cytokinin. The other medium constituents, except sucrose, are reduced to half concentration.

Pear shoots root synchronously with root initials visible after 10 days. This allows rooting of many shoots in one culture vessel containing the agar medium. Apples, on the other hand root irregularly, some after 10 days, others after 40 days, so are incubated individually in test tubes to allow transplanting at the correct stage of root development. Rooting success, with both apples and pears, is about 80%, much higher than with cuttings in the greenhouse. Perhaps the explanation for this is better control of exposure of the shoot to the root initiating auxin and because of the ready reserve of carbohydrate in culture (rooting decreases if sugar concentration is reduced).

After root initiation, pears can be transplanted directly to the mist bed where functional roots develop, leaves accumulate the usual waxy covering and normal growth begins. Apples, if handled like pears, don't survive as well. Apples are allowed to develop further, after root initiation, in an auxin-free medium before transplanting into the mist bed.

Apples are more susceptible to root rot disease than pears so misting frequency must be minimized and a coarse potting mixture used to ensure good drainage. When these conditions are met, transplanting losses are less than 5%. After 2 weeks in the mist bed, both pear and apple plants are repotted and grown in a greenhouse until transplanted outside or put into cold storage.



A B C

Figure (A) Apple shoot culture. Shoots are cut off and rooted in another medium, the remaining base regenerating more shoots. Each jar produces 20 shoots every 3 weeks. (B) Pear shoot culture. This prolific culture produced 80 shoots suitable for rooting in 1 month. Multiple shoot cultures take about 6 months to establish and can be maintained indefinitely. (C) Test tube propagated pears. Rooted shoots are hardened off in mist bed then grown like normal plants. Self-rooted cultivars from culture could be more quickly and in greater numbers than using normal procedures.

The time required for establishing tissue cultures from field trees and production of the first plants is about 6 months. The number of producing cultures can easily be expanded by using cultural shoots to initiate new mother cultures. Plant production can be expanded accordingly.

The tissue culture system is flexible, and can be adjusted to changes in demands for different kinds of trees much more quickly than is possible using traditional methods. Unlike outdoor propagation it is largely independent of climate and season.

Full scale commercial production of test tube fruit trees remains to be demonstrated. Best guesses are that rootstock liners (small plants that must be grown for a year before budding) can be produced as cheaply as in stoolbeds. They would, however, have the advantage of being available on shorter notice and in larger quantities.

Production of self-rooted trees of fruiting cultivars would be a departure from normal practice

of grafting onto a rootstock, but such a self-rooted characteristic may be useful. For example, most of the rootstock cultures we use originated in Europe and have not been as rigorously selected for hardiness as have Canadian fruiting varieties. Because of this deficiency there is extensive use of hardy seedling rootstock and the advantages of the clonal rootstocks, such as dwarfing and lack of genetic variation, are lost. Self-rooted spur strains could also be more dwarf than the same strain on seedling rootstock as well as equally hardy. This potential advantage, however, has not yet been proven.

The most important advantage of self-rooted varieties is lower cost. How much lower would depend on how small a tree a farmer can successfully transplant to his orchard. Large trees, if used, would have to be grown in nurseries increasing the cost, but new management practices are being devised for orchard planting of trees 18 inches tall. This size can be reached in 6 weeks in a greenhouse using a 4 inch diameter pot. Self-rooted trees from tissue culture should be well suited to such systems.

Our experience with test tube propagation of fruit trees is accumulating rapidly and it will be interesting to see how much time will be needed for commercial production and orchard management systems to take full advantage of the potential. More research will develop new uses of the technology and perhaps revision of present ideas will be required as this new approach to propagation comes of age. Certainly there is much research to be done in this exciting field.

Dr. Lane is a fruit breeding specialist at Agriculture Canada's Research Station, Summerland, B.C.

SMEP — AN APPROACH TO AERIAL ASSESSMENT OF SOIL MOISTURE RESERVES IN THE PRAIRIE PROVINCES

S.N. EDEY

Le Programme d'évaluation du taux d'humidité du sol (PETHS) vise, à l'aide d'un ordinateur, à fournir des renseignements sur la quantité d'humidité disponible dans le sol à tout temps et tout endroit dans les régions céréalières des Prairies. Il a été lancé en 1976 par la section d'agrométéorologie de l'Institut de recherche sur les terres d'Agriculture Canada. Des cartes sont à la disposition des producteurs afin de les aider à prendre des décisions concernant le taux de semis, les semis sur chaume, l'application d'engrais chimiques ainsi que l'irrigation et la gestion des sols salins.

In spite of much technological progress in agricultural production, the weather is still a major factor in operating a farm, creating wide variations in crop yields from year to year and causing other farm problems. The weather is seldom ideal for any extended period of time during the growing season and its effects must be taken into account in farm planning. In the Prairies, particularly Alberta and Saskatchewan, rainfall is usually the limiting factor in cereal crop production. For this reason, the Agrometeorology Section of the

Land Resource Research Institute, Agriculture Canada, initiated a study in 1976 called the Soil Moisture Evaluation Project (SMEP). The objective of the project was to develop a method for evaluating available soil water for crop production for various soil textures, on a real time basis, at any time during the year. An important consideration in doing this was the fact that the only input to the system is readily available meteorological data. Conventional methods for measuring soil moisture are often difficult for remote areas and are particularly laborious and impractical during the winter and early spring. The SMEP system with its proven soil moisture evaluation ability has been successful. At the present time it is the only system with a daily operational mode that is capable of evaluating soil moisture reserves on a real time basis over large geographic areas. Originally the test area covered the major cereal producing areas of Saskatchewan. However, in 1977 the test area was expanded to include similar regions in Alberta and Manitoba. Daily weather information from a selected number of climatological observing stations in the three Prairie Provinces is assembled at the Central Experimental Farm in Ottawa. These data are entered into the Agriculture Canada computer at the beginning of each week. The stored information is then used to estimate the plant available water on a daily basis using the Baier-Robertson soil moisture budgeting technique. A computer mapping program "Symap" is used to produce a series of maps of soil moisture reserves from the estimated point values.

Six maps depicting the current moisture reserves are produced weekly for three soil textures: a light or coarse soil (sandy) with a plant available water capacity of 150 mm (approx. 6 in.); a medium soil (loam) with a plant available

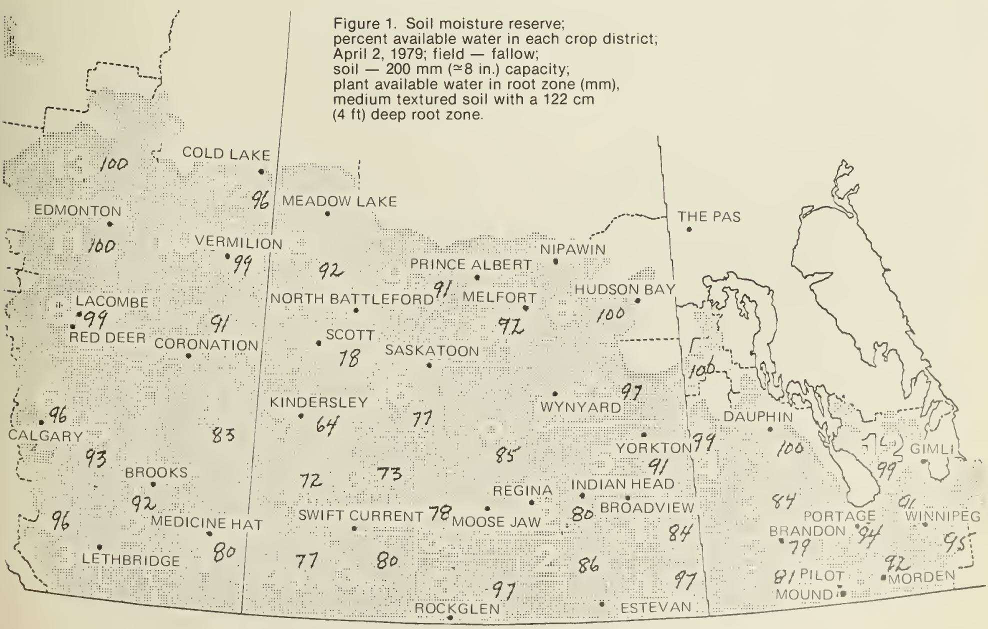


Figure 1. Soil moisture reserve; percent available water in each crop district; April 2, 1979; field — fallow; soil — 200 mm (≃8 in.) capacity; plant available water in root zone (mm), medium textured soil with a 122 cm (4 ft) deep root zone.

water capacity of 200 mm (approx. 8 in.); and a heavy or fine soil (clay) with a capacity of 280 mm (approx. 11 in.). Two field conditions, stubble and fallow are also considered. Since cereal production statistics in the Prairies are collected on the basis of crop reporting districts within each province, the base map used in the program (Figure 1) is based on crop districts. The values given for each crop district represent the percentage plant available water (PAW) for the district. In Figure 1, the written numbers (77, 80, etc.) indicate an average PAW for fallow, medium textured soils in each of the crop reporting districts. Similar maps are produced for stubble crops, and for lighter and heavier textured soils. The district value is computed from the original point data using a polygon weighting method. On soils with less than 100 mm (4 in.) of water indicated, a production problem can be expected if the growing season rainfall is below normal. Consequently, the maps offer an instant, pictorial evaluation of existing and potential problem areas.

Other types of maps are also produced. For example, snow cover maps in early spring (Figure 2), showing the potential amount of snowmelt water available to the soil from the existing snow cover at a particular time of year, can be produced to assess the soil moisture situation early in the year.

Later in the spring, a map depicting the depth of moist soil for stubble land (Figure 3) provides information of particular importance to the farmer prior to planting time when operational decisions for seeding stubble, controlling salinity, and the maintenance of farm productivity must be made. It is important to know how much soil moisture is available in the field at planting time, since the availability of existing soil moisture must be considered when determining

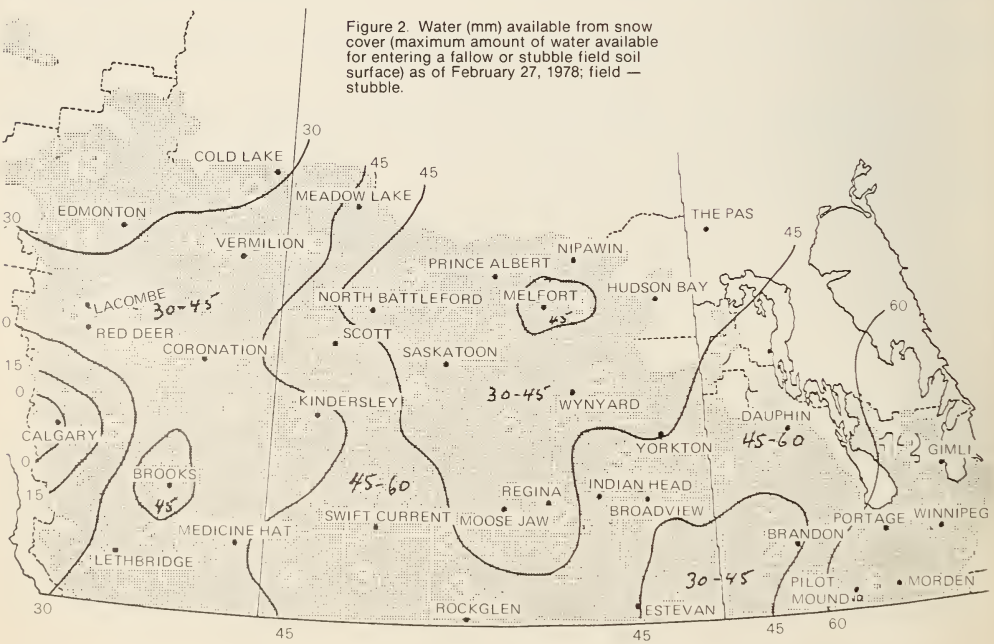


Figure 2. Water (mm) available from snow cover (maximum amount of water available for entering a fallow or stubble field soil surface) as of February 27, 1978; field — stubble.

whether or not to plant, what to plant, what seeding rate and row spacing to use and how much fertilizer should be applied. To illustrate, the recropping of stubble land is considered a good risk when the soil contains a minimum of 100 mm (4 in.) of plant available water. As a rule of thumb, this requires moisture to the following depths: 45 cm (18 in.) in clay soils, 60 cm (24 in.) in loam soils, and 75 cm (30 in.) in sandy soils. Average rainfall during the growing season is necessary to ensure average crop yields.

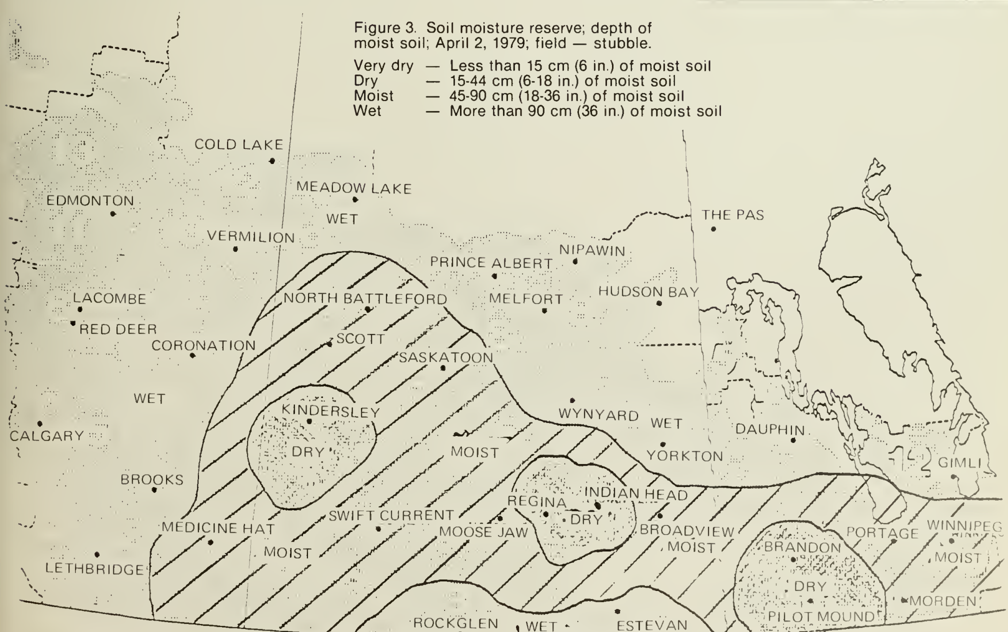
Another advantage of knowing the availability of plant water to crops at critical growth stages during the growing season is that stress periods can be related to expected yields. Under dryland conditions there is little the farmer can do, but with irrigation farming supplemental water can be added as required to maintain normal yields. A further objective of the SMEP program is to develop a yield index based on soil moisture and temperature stress, which can be used to evaluate crop yield potential, not only in Canada, but in other cereal producing regions of the world. This would enable marketing agencies to plan marketing strategies with resultant advantage to the producers.

The accurate prediction of final crop yields will still rely on the long-range forecast of growing season rainfall, but to date this capability has not been developed. Nevertheless, the real-time evaluation of existing soil moisture reserves together with long-term rainfall statistics can provide a more definitive assessment of yield potential than previously, and this coupled with the provision of information for decisions at the farm level provides evidence of the value of the SMEP program.

Mr. Edey is a climatologist with the Agrometeorology Section, Land Resource Research Institute, Agriculture Canada, Ottawa.

Figure 3. Soil moisture reserve; depth of moist soil; April 2, 1979; field — stubble.

Very dry — Less than 15 cm (6 in.) of moist soil
Dry — 15-44 cm (6-18 in.) of moist soil
Moist — 45-90 cm (18-36 in.) of moist soil
Wet — More than 90 cm (36 in.) of moist soil



COMPARING SHEEP BREEDS FOR LAMB PRODUCTION IN WESTERN CANADA

J.A. VESELY

Toute information relative à la productivité de diverses races de moutons élevés sous les conditions qui prévalent dans l'Ouest s'avère très importante pour les producteurs ovins de cette région. La Direction de la recherche d'Agriculture Canada a effectué plusieurs expériences pour évaluer le potentiel de productivité des races les plus populaires de l'ouest canadien. L'article suivant résume et confronte les résultats de ces expériences.

Information on the production performance of various breeds of sheep under western range conditions is important to sheep producers in that area. Agriculture Canada's Research Branch has conducted several experiments evaluating the production potential of the most popular sheep breeds in Western Canada.

This article summarizes the highlights of these comparison experiments which have been reported in scientific papers[1]. The data were collected from four different periods between 1953 and 1978. Since management and experimental procedures have changed during these 26 years, relative ranking only can be obtained, not the actual performance of breeds.

Breeds tested were those suitable for the western range: at first the Rambouillet and later the Canadian Corriedale, Romnelet, Romeldale, Columbia and Targhee. These breeds represent the majority of sheep in the west known as "white-face" range sheep. They are all related and have some Rambouillet blood. Besides the six range breeds, Suffolk and North Country Cheviot, the most popular mutton breeds in Western Canada, were tested.

In the last phase of the breed testing, Dorset Horn and Finnish Landrace rams were investigated and the prolificacy of the half-Dorset and half-Finnish Landrace females assessed.

Four traits were used to compare the performance of the eight sheep breeds:

- prolificacy of ewes (number of lambs born per 100 ewes lambing);
- the lambs' weaning weight;
- overall lamb production per ewe expressed as weight of lamb weaned per ewe exposed to ram; and
- the growth rate of the lamb in the feedlot.

Prolificacy was somewhat variable among the breeds in the first experiment; however, the levels were not significantly different (Table 1). The second experiment confirmed that all range breeds generally have the same prolificacy (Table 2). However, Suffolk, a mutton breed, averaged 20 lambs per 100 ewes higher than that of the range breeds (Tables 2 and 3). The N.C. Cheviot, the other mutton breed, appeared to be between the Suffolk and the range breeds (Table 3).

The Rambouillet had the heaviest lambs at weaning of all range breeds (Tables 1 and 2). In the second experiment the Targhee showed the same ranking as Rambouillet. Lambs of the other range breeds were about equal in this trait but somewhat lower than Rambouillet and Targhee (Tables 1 and 2). The heaviest overall weaning weights were exhibited by the Suffolk and the lightest by the N.C. Cheviot (Tables 2 and 3).

The weight of lamb weaned per ewe exposed to ram was about the same for all six range breeds (Tables 1, 2 and 3). The Suffolk was significantly superior (Tables 2 and 3) and the N.C. Cheviot was significantly inferior (Table 3) to all breeds.

Feedlot gain was not tested in experiment 1. However, the results of experiments 2 and 3 demonstrated that feedlot gains of the range breeds are about the same and that gain of the Suffolk was superior (Tables 2 and 3).

Mortality rates of the Romnelet, Columbia, Suffolk and N.C. Cheviot were similar during their first four years. After that, the mortality rate increased in the N.C. Cheviot flock. The same phenomenon was observed in the Suffolk flock after six years. At the end of eight and one-half years the percentage of ewes remaining in the Romnelet flock was 22%, Columbia 25%, Suffolk 5% and N.C. Cheviot 0%. The average lifetime lamb produc-

TABLE 1. REPRODUCTION AND PRODUCTION TRAITS OF RAMBOUILLET, ROMNELET, CANADIAN CORRIEDALE AND ROMELDALE BREEDS OF SHEEP MEASURED IN YEARS FROM 1953 TO 1956 (EXPERIMENT 1)

Breed	Ewes exposed to rams	Prolificacy: Lambs born per 100 ewes lambing	Weaning wt (kg)	Wt of lamb weaned per ewe exposed to ram (kg)
Rambouillet	174	138	32.1	34
Romnelet	200	135	28.8	32
Can. Corriedale	196	145	27.4	30
Romeldale	199	154	28.0	30

[1]Further details and copies of these papers are available from the author.

TABLE 2. REPRODUCTION AND PRODUCTION TRAITS OF RAMBOUILLET, ROMNELET, COLUMBIA, TARGHEE, AND SUFFOLK BREEDS OF SHEEP MEASURED IN THE YEARS FROM 1960 TO 1963 (EXPERIMENT 2)

Breed	Ewes exposed to rams	Prolificacy: Lambs born per 100 ewes lambing	Weaning wt (kg)	Wt of lamb weaned per ewe exposed to ram (kg)	Gain/day of feedlot (kg)
Rambouillet	158	157	33.9	42	0.15
Romnelet	159	157	32.4	42	0.13
Columbia	158	156	32.1	41	0.16
Targhee	159	150	33.7	43	0.18
Suffolk	158	181	34.4	49	0.20

TABLE 3. REPRODUCTION AND PRODUCTION TRAITS OF ROMNELET, COLUMBIA, SUFFOLK, AND NORTH COUNTRY CHEVIOT BREEDS OF SHEEP MEASURED IN THE YEARS FROM 1964 TO 1973 (EXPERIMENT 3)

Breed	Ewes exposed to rams	Prolificacy: Lambs born per 100 ewes lambing	Wt of lamb weaned per ewe exposed to ram (kg)	Total feedlot gain (kg)
Romnelet	212	143	25.3	12.2
Columbia	209	147	27.0	11.2
Suffolk	204	162	31.4	12.6
N.C. Cheviot	154	153	20.1	9.9

TABLE 4. BREEDS RANKED BY WEIGHT OF LAMB WEANED PER EWE EXPOSED TO RAM WITH RANKINGS FOR PROLIFICACY, WEANING WEIGHT, AND LIFETIME PRODUCTION OF LAMB PER EWE

Breed	Prolificacy	Weaning weight	Weight of lamb weaned per ewe exposed to ram	Lifetime production of lamb per ewe
Suffolk	1	1	1	1
Rambouillet	3	2	2	†
Romnelet	5	4	3	2
Romeldale	6	6	4	†
Targhee	7	3	5	†
Columbia	4	5	6	3
Canadian Corriedale	8	7	7	†
N.C. Cheviot	2	8	8	4

†Not measured.

tion per ewe was 149.5 kg for Suffolk, 146.6 kg for Romnelet, 119.3 kg for Columbia and 92.1 kg for N.C. Cheviot.

Summarizing breed comparisons Suffolk proved to be the best in lamb production. The range breeds represented by Rambouillet, Romnelet, Romeldale, Columbia, Targhee and Canadian Corriedale have equal potential for lamb production and the ranking among them is not significant (Table 4). There might be other factors in setting priorities of one over the others, for example the breed's temperament, general ease of handling, confirmation affecting prices of feeder and finished lambs and wool quality and quantity. The N.C. Cheviot was ranked at the bottom of the scale in lamb production. However, based on results from our crossbreeding experiments, this breed can be useful in crossbreeding systems.

If Dorset Horn and Finnish Landrace sires are used to produce crossbred breeding ewes in a practical breeding program, only a proportion of the ewe lambs would be retained for breeding; the remainder and the wethers would be fed out and sold. The growth potential and carcass grades of lambs sired by Dorset Horn or Finnish Landrace rams were determined. Weaning weights and weight-per-day-of-age to market were the same for both groups. Carcasses from Finnish sires were of a slightly better average grade than those from Dorset ewes, mainly because they were leaner. Therefore, when used as sires to produce crossbred breeding ewes, both Dorset and Finnish rams will produce crossbred lambs with satisfactory growth and carcass merit.

In prolificacy tests for half-Dorset and half-Finnish ewes, average lambing rates (number of lambs born per 100 ewes lambing) based on three consecutive lamb crops when the ewes were one, two and three years old were half-Dorset 169 and half-Finnish 242. These results prove that the Finnish breed has a great potential for increasing prolificacy.

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